Tropnet: The First Large Small-Satellite Mission

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Abstract. Every small-satellite enthusiast has hoped for the day when small satellites would gain the sophistication, political support and commercial viability to be used for main stream missions. The first phase of such a mission is currently being constructed by One Stop Satellite Solutions (OSSS) of Ogden, Utah and will launch May of 2002. The OS-2 payload will be delivered into a 650-km orbit using a Russian Dnepr launch vehicle furnished by the launch team of Kosmotraus and Thiokol. Aboard the OS-2 mission will be two satellites, which will demonstrate technical feasibility of the TropNet concept. TropNet is an equatorial LEO constellation of 16 bent-pipe style communications satellites of the 50-kg class.

The phase 1 mission in May will verify structural design, power generation and storage, active and passive attitude control, orbit station keeping and communications link budget. Phase 2 of this project is scheduled for launch in late 2003 and to begin commercial services in early 2004. In addition to 16 satellites, 16 earth stations located at strategic points around the world will be constructed. TropNet will service the commercial wholesale telecommunications market and will bring services into remote areas.

Introduction

One Stop Satellite Solutions and it academic partner, the Center for AeroSpace Technology (CAST), has the goal of developing the commercial potential; of small satellites. The OS-2 mission which will be launched May 2002 will accommodate two commercial missions that are specifically design as small satellite missions. Over twenty university and government organizations as well as several commercial partners are making this historical event happen.

History

As shown in the time line of Figure 1, CAST and OSSS has been involved in building and flying satellites for 20 years.

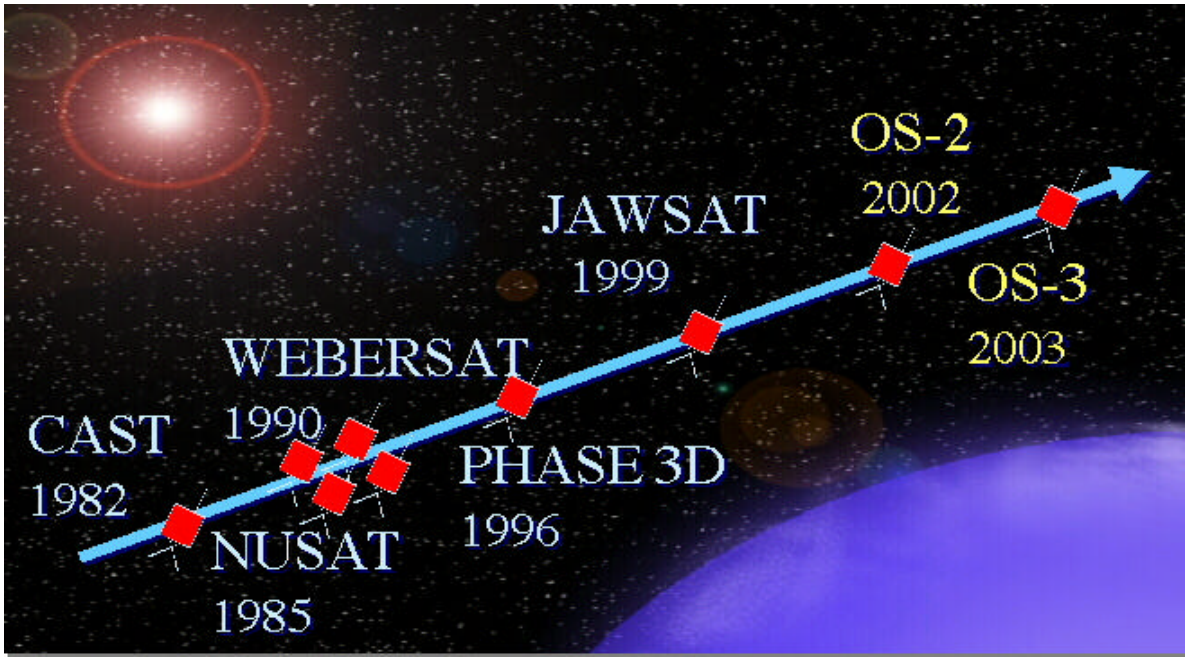

Figure 1 – OSSS/CAST Timeline of Missions

NUSAT I (Northern Utah Satellite)

CAST started with the Northern Utah Satellite. NUSAT I was constructed in the early 80's, launched in 1985 from the Challenger Space Shuttle and has the distinct honor of being the first satellite designed, built, and flown by an undergraduate school. The prototype is currently in the National Air and Space Museum at the Smithsonian Institute. NUSAT I, see Figure 2, was in orbit for 18 months and was designed to study high altitude radar field patterns for the Federal Aviation Administration.

AmSat

The Amateur Satellite Corporation (AmSat) has a long history of building communications satellites to support amateur or 'Ham" radio needs. The North American branch of this international organization asked CAST to participate in the fabrication of four micro satellites. These satellites measure only 9 inches on a side and weigh less than 25 pounds.

Figure 2 – NUSAT I Satellite

For their contribution, CAST received ownership of WEBERSAT, one of the four microsats. The four were launched January 22, 1990 as a piggyback payload on an 'Ariane IV' rocket of the European Space Agency. The microsats are spin stabilized and offer store and forward amateur packet communications around the globe.

WEBERSAT

The geometry of WEBERSAT is shown in Figure 3. Beyond the basic hardware common to the four microsats, WEBERSAT also contains additional experiments designed and constructed by student senior project groups. They include a particle impact detector, optical spectrometer, sun sensor, earth horizon detector, fluxgate magnetometer, and an onboard color CCD camera experiment.

Figure 3 - WEBERSAT Satellite

Over 300 students from Electronic Engineering Technology, Mechanical Engineering Technology, Manufacturing Engineering Technology, Computer Science, Mathematics, Physics and the local high schools have put in over 20,000 hours into the WEBERSAT project either in the initial design and construction phase or in interpreting the experimental results from the orbiting satellite.

Phase 3d

In 1997 CAST completed the fabrication and qualification of the spaceframe for a full-size communications satellite for AMSAT. The Phase 3d is a 1500 hundred pound satellite carrying 11 amateur radio transponders. This international communications spacecraft was launched November 2000.

Figure 4 – AMSAT Phase 3D Satellite

JAWSAT

The combined groups of One Stop Satellite Solutions (OSSS) and the Center for Aerospace Technology (CAST) recently com-

pleted the Joint Air Force Academy Weber State University Satellite (JAWSAT) mission. After four years of planning, building and testing, a successful launch occurred

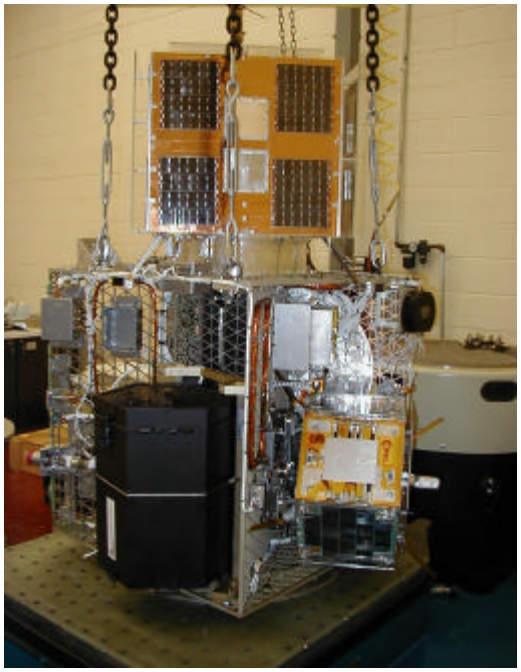

Figure 5 - JAWSAT Satellite

on January 26, 2000. JAWSAT became the first orbital launch of the new millennium and the first payload to be placed into orbit using the Minotaur launch vehicle. Minotaur was also the first launch vehicle created from surplus Minuteman ICBM components. This project has many other firsts which include: deployment of 11 independent satellites from a single Multi-Payload Adapter (MPA), the first three-axis attitude controlled bus for under five million dollars, broad, cross-organization, teaming and web based documentation with distributed management techniques.

To date, OSSS has partnered with or provided services for several departments of the U.S. Air Force (Air Force Academy, Space Test Program, Space Missile Command, Airforce Research Laboratory, Starfire Optical Range, Space Vehicle Directorate), NASA Marshal Space Flight Center, Air Force and Army Space Battlelabs, Stanford and Arizona State Universities, Orbital, TRW, Boeing, and Thiokol. OSSS's international marketing efforts have been very positive with major contracting in Japan, Korea, France, Australia and Russia.

OS-2

In May of 2002 the OS-2 payload will be delivered into a 650-km orbit using a Russian Dnepr launch vehicle furnished by the launch team of Kosmotraus and Thiokol. The orbit will be sun-synchronous polar.

As in the JAWSAT mission, OS-2 will accommodate many small experiments, free

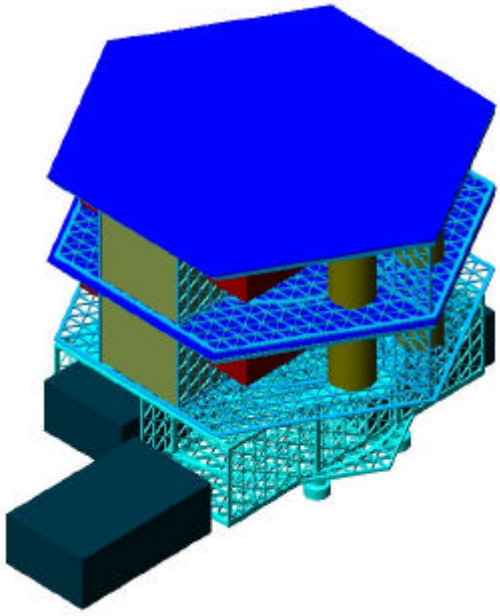

Figure 6 – OS-2 Stack

flyers and independent spacecraft into one stack for launch. The OS-2 stack will be one meter in cross-section and one meter in height. The mass will be about 120 kg.

As shown in Figure 6, OS-2 has three main sections, each with a different mission.

CubeSat

Once in orbit and separated from the launch vehicle, the on-board computer will use moment reaction wheels to eliminate spacecraft spin and point the stack to the desired direction. Eighteen separate CubeSats of various sizes will be deployed radially from the bottom platform.

Figure 7 – CubeSat Satellite

CubeSat customers on this first mission include:

- Montana State University
- Taylor University
- Stanford University
- California Polytechnic
- University of Tokyo
- Tokyo Institute of Technology
- Wilcox High School
- Arizona State University
- Leland High School
- UC Santa Barbara
- Reverend Arthur Blessit
- NASA/Stanford Space Biology Center

Each of these payloads is a free flying satellite based on the Stanford University concept as shown in Figure 7. Each platform can hold, launch and deploy up to 28 CubeSats. (See Figure 8.) OSSS plans to have two CubeSat missions a year as the market demands. Some will be on US launches to accommodate DoD missions.

TropNet

After deployment of the CubeSats, the flight computer will establish a spacecraft spin about the vertical axis and decouple from the bottom platform. This spin stabilize platform now becomes a test element of a TropNet constellation.

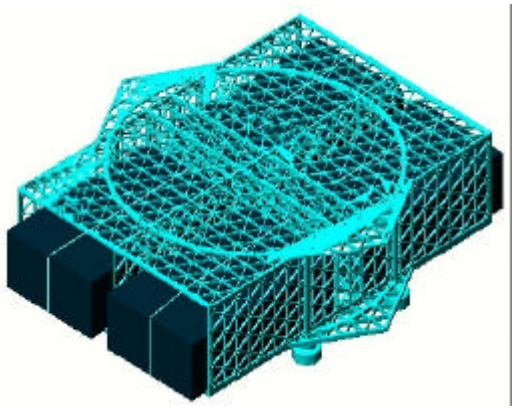

Figure 8 – CubeSat Platform

A microwave plasma engine created by Astro Research of Fujisawa Japan will then propel the upper stages to about 500 kms ahead in the orbital trajectory.

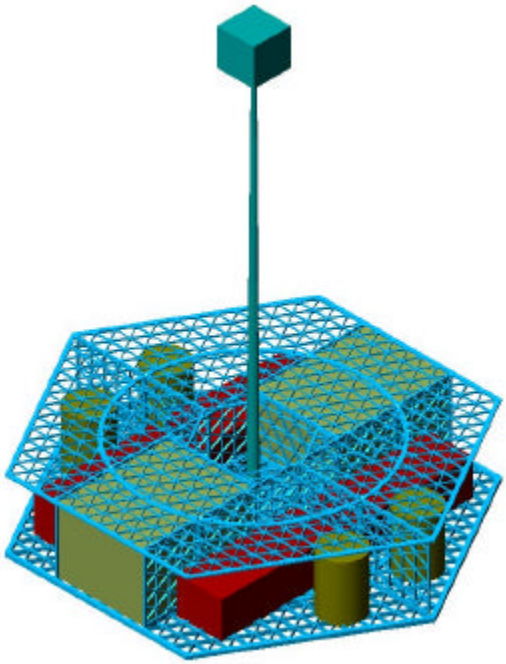

Figure 9 – TropNet Satellite

After despin, a new technology gravity gradient boom is deployed from the second stage as per Figure 9. The attitude control system will place the second stage into near gravity gradient configuration and separate.

The third stage engine will again separate the sections by about 500 km. This procedure creates three communications satellites about 500 km apart. The first is spin stabilized, the second gravity gradient stabilized and the third is reaction wheel stabilized and has maneuvering capability. This constellation of three satellites will be used to demonstrate spacecraft, systems and communication for the TropNet constellation of 16 satellites to be launched in 2004.

Conclusion

In all, the OS-2 mission will launch and deploy 12 educational satellites, 3 commercial satellites for scientific research, one non-scientific commercial satellite and three prototype communication satellites on one launch platform.